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Proposed Topic of Research

An optimum Cluster Based Routing Protocol In Mobile Adhoc Networks

Objectives of the Proposed Research

Our goal in this research is to evaluate the performance of Cluster Based Routing Protocol in Mobile Ad hoc Networks and to propose a new clustering scheme involving less control overhead in maintaining cluster structure. And finally propose a new improved cluster based routing protocol.

In order to compare the performance of clustering schemes and cluster based routing protocol, the research work will focus on the following metrics for performance evaluation:

1. Packet Delivery Fraction: The ratio of the data packets delivered to the destinations to those generated by the sources.
2. Channel utilization capacity: This metric gives the fraction of channel capacity used for data transmitted by the network and is computed as

$$CU\left(\%\right) = \frac{PR * SZ}{SET * BW}$$

where PR is the number of data packets received by the destination nodes, SZ is the size of the data packets, SET is simulation end time and BW is the nominal channel bandwidth.

3. Average end-to-end delay: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.
4. Normalized routing load: The number of routing packets transmitted per data packet delivered at the destination.
5. Control Overhead: The total number of non data packets transmitted by the protocol. In DSR, routing overhead (ROH) that is the total number of routing packets transmitted during the simulation is the main source of control overhead. For CBRP, the control overhead is the sum clustering overhead (COH) and routing overhead. Clustering overhead is the number of clustering messages sent by each node in cluster formation and cluster maintenance operation. It is an important measure for the scalability of a protocol. If a protocol requires sending many control packets, it will most likely cause congestion, collision and data delay in larger networks
6. The number of clusterhead change is the total number of clusterhead changes during the whole simulation run time. A small value of clusterhead change reflects the stability of the cluster structure.

7. The number of cluster member change is the number of mobile nodes that switch to another clusterhead during the simulation run time.

8. Clustering overhead is the number of clustering messages sent by each node in cluster formation and cluster maintenance operation. It is an important measure for the scalability of a protocol.
9. A modified / new clustering algorithm may design to reduce the control message exchanges for maintaining cluster structure so that minimum number of clusterhead and clustermember changes, to maintain stable clusters and to minimize the number of clustering overheads.
10. The modified / new clustering algorithm scheme are simulated and compared in terms of packet delivery fraction, channel utilization, normalized routing load, control overhead and average end to end delay with respect to varying mobility.

11. By using Non Traditional Optimization techniques such as Genetic Algorithms for Routing Optimization using Genetic Algorithm in Ad Hoc Networks [20], Ant Colony Optimization (ACO) Effective Cluster Head Selection [21].

Background of the Proposed Research

Introduction:

Mobile Ad hoc networks are autonomous system of mobile nodes, in which communication is directly between nodes or through intermediate nodes acting as routers that utilize multi-hop radio relaying and are connected by wireless links without any support of preexisting communication infrastructure or centralized administration. This requires each mobile host to be more intelligent to perform both the transmission and receiption of data and to forward packets to other node as a router. Such systems provide rapid deployment, robustness, flexibility and inherent support for mobility. Due to their quick and economically less demanding deployment, they find applications in military operations, collaborative and distributed computing, emergency operations, wireless mesh networks, wireless sensor networks and hybrid networks.

Lack of fixed infrastructure and frequent link failure restricts the use of traditional routing for wired networks to mobile ad hoc networks directly, as wired routing assume the network to be stable and overhead to be almost negligible. They either lack the ability to adapt to dynamic topology of mobile ad hoc networks or cause a large overhead which may degrade the network performance. Therefore, routing is the most studied problem in mobile ad hoc networks and a number of routing protocols have been proposed [1-13] in recent past, derived either from *distance-vector* [14] or *linkstate* [15] based on classical routing algorithms.

Routing protocols for Mobile ad hoc networks can be classified in two main categories based on routing information update mechanism as Proactive or table driven routing protocols and Reactive or on-demand routing protocols. In proactive protocols, every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Destination Sequenced Distance Vector (DSDV) [2], the Wireless Routing Protocol (WRP) [3], Source-Tree Adaptive Routing (STAR) [5] and Cluster-head Gateway Switch Routing protocol (CGSR) [4] are some of the existing proactive protocols. On the other hand, reactive protocols obtain routes only on

demand, which include Cluster Based Routing Protocol (CBRP), Dynamic Source Routing (DSR) protocol [6], the Ad hoc On-demand Distance Vector (AODV) protocol [7], the Temporally Ordered Routing Algorithm (TORA) [8], and the Associativity Based Routing (ABR) protocol [10].

Routing protocols may also be classified as flat or cluster based depending on underlying topology. A flat architecture exclusively based on proactive or on reactive routing approaches cannot perform well in a large MANET [16–18] due to their scalability problems with increased network size, particularly with node mobility. Proactive routing is table–driven and requires control overhead for building and updating the table containing information about the state of the network. The control overhead for proactive routing protocols is of the order of square of total number of nodes in a network [19]. Whereas in reactive routing protocols routes are found on demand which incur significant route setup delay that becomes intolerable in the presence of both a large number of nodes and mobility. Therefore, both proactive and reactive routing schemes are not scalable in flat architecture.

Clustering is a known technique in the area of distributed network computing in which the local properties of a network are used to speed up a computation by sharing information, preferably inside of a local group or cluster. The overall load on the network is decreased by performing as much computation as possible locally and sending out data that in some sense represents all nodes in a cluster. As the load depends generally on the number of nodes in a group, clustering is needed to make a protocol scalable.

Clustering algorithms are based on the partition of the network into groups. A clusterhead is selected in each group. Clusterheads are interconnected by gateways (nodes which forms part of more than one cluster) to carry out the routing process. Within a cluster, the nodes have complete topology information about its cluster and use proactive routing. If the destination is in a different cluster from the source, intercluster routing, which generally may be reactive or a combination of proactive and reactive routing, is used.

Clustering is important for a network to achieve scalability in presence of a large number of mobile nodes and high mobility. However, constructing and maintaining a cluster structure usually requires additional control overhead compared to a flat-based structure in an ad hoc wireless network. This additional control overhead involved in clustering is a key issue to validate the effectiveness and scalability enhancement of a cluster structure.

Literature Review of Research Topic

In clustering schemes mobile nodes in a MANET are partitioned into different virtual groups, called clusters. Nodes geographically adjacent are allocated the same cluster, according to some criteria. The size of the cluster depends on the radio range of the nodes.

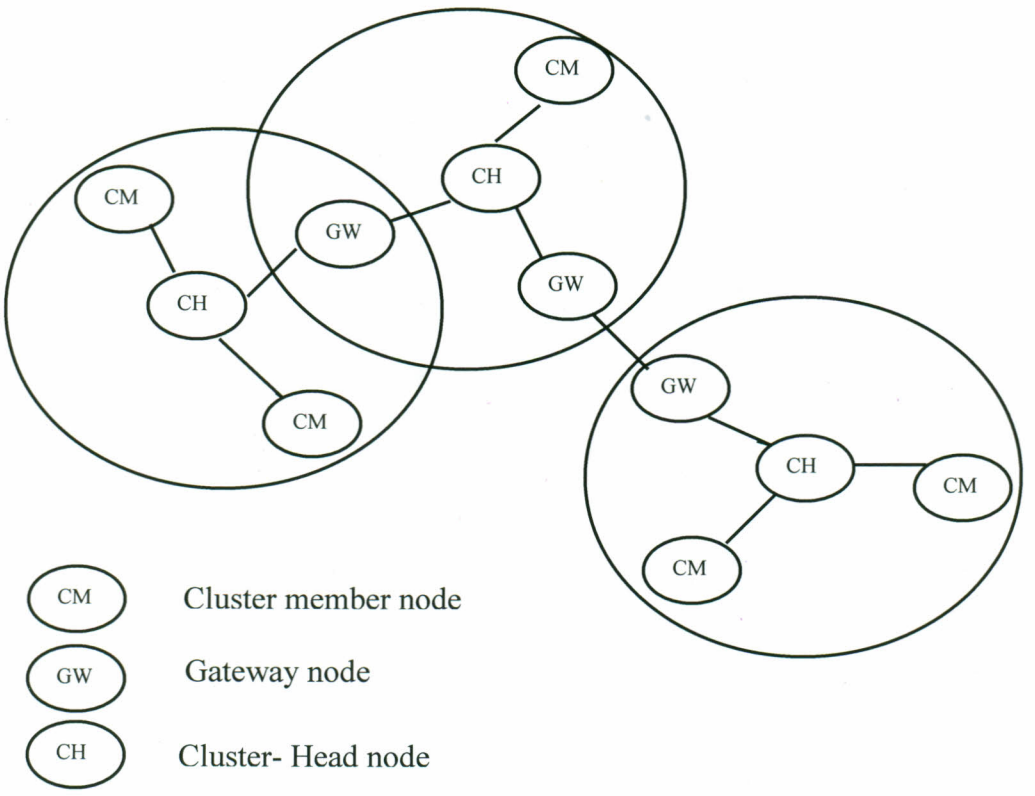


Figure: Cluster Structure showing clusterhead, cluster member and Gateway nodes.

The cluster structure, shown in above Fig., consists of three types of nodes: clusterhead (CH), cluster member (CM) and cluster gateway (GW). In each cluster one node is elected as the clusterhead to act as a local coordinator for its cluster performing intra-cluster transmission arrangement and data forwarding. Communication between two clusterheads takes place through gateway nodes. A gateway is a node that has two or more clusterheads as its neighbors, when the clusters are overlapping or at least one clusterhead and another

gateway node, when the clusters are disjoint. A clustermember is a non-clusterhead node without any inter-cluster links.

Clustering consist of two phases: Cluster formation and Cluster maintenance. Cluster formation deals with building of cluster structure whereas cluster maintenance deals with updating the cluster structure according to the changing network topology and is quite important as it is related to the performance of the given clustering algorithm in a dynamic environment.

In many application scenarios like military, environmental monitoring and health monitoring large-scale MANETs are desirable. Hierarchical network architecture seems to be a promising solution to remove the performance bottleneck in flat architecture to serve such applications. Therefore, a cluster structure, which is basically a hierarchical arrangement of nodes, is essential to address the scalability issue in MANETs, to achieve the desired performance guarantee. As an effective topology control means a cluster structure provides following benefits.

- A cluster structure makes spatial reuse of resources; the same frequency or code set can be used by two clusters if they are not neighboring clusters and increase the system capacity [50, 51]. With the help of a special mobile node such as clusterhead it can better coordinate the transmission events. This saves much resources used for retransmission due to collisions.
- The set of clusterheads and cluster gateways, which are far fewer in number than all the nodes in the network, normally form a virtual backbone for inter-cluster routing which requires less generation and spreading of routing information and are expected to consume less control overhead. This reduction in control overhead is significant in terms of energy efficiency.

- A cluster structure makes MANET to appear smaller and more stable. When a mobile node changes its attached cluster it affects only the associated cluster and not the entire network [52]. Thus local changes within a cluster need not to be updated by the entire network and hence information processed and stored by each mobile node is greatly reduced.

Clustering is important as it makes a network scalable in the presence of a large number of mobile nodes and high mobility. However, a MANET based on clustering has its side effects and drawbacks too. Clustering usually requires additional control overhead, for constructing and maintaining a cluster structure, as compared to a flat structure based MANET. This control overhead in clustering is a major concern with respect to the effectiveness, energy efficiency and scalability enhancement of a cluster structure. The major constituent of clustering overheads is:

- Explicit messages are exchanged between mobile nodes in order to maintain a cluster structure in a dynamic topology. This cluster related information exchange increases drastically with rapid topology change and also with more number of mobile nodes. Frequent information exchange may consume considerable bandwidth and drain mobile node's energy quickly.
- The movement or death, due to energy drain, of a mobile node results in some clusterhead re-election. The re-election of one clusterhead may affect the structure of many clusters and cause the clusterhead re-election over the network. This, the ripple effect of re-clustering, may greatly affect the performance of upper-layer protocols.
- The number of rounds in which a cluster formation procedure can be completed is known as computation round. For clustering schemes relying on a assumption of stable nodes during cluster formation (called as frozen period), the computation round is an important

metric since the more rounds that a clustering scheme requires for its cluster formation, the longer the frozen period is required for mobile nodes.

Hence, the required explicit control message exchange, the ripple effect of re-clustering and the stationary assumption for cluster formation are the main overhead constituent in a cluster-based MANET.

Various clustering schemes are proposed in the literature [50, 28-49]. These schemes are broadly summarized and classified here based on.

- ***Cluster maintenance*:** These schemes aim at providing stable cluster architecture for upper-layer protocols with little cluster maintenance cost. Limiting the re-clustering situations, by prolonging the clusterhead change or minimizing explicit control messages for clustering, the cluster structure can be maintained well without excessive consumption of network resources for cluster maintenance. LCC [28], 3hBAC [29], Lin's algorithm [50] and Passive clustering [30] are some of the examples of low maintenance clustering schemes.
- ***Graph theory*:** These schemes tries to select a small number of mobile nodes to act as a set of dominating nodes so that the routing information and data packets are relayed only through the nodes in the dominating set only. Thus the overhead in route search or routing table maintenance is reduced. Wu's CDS [40] and Chen's WCDS [41] are the examples of this type.
- ***Energy-efficiency*:** The energy of node in a MANET is limited hence MANET should reduce its energy consumption in order to prolong the life time of the network. A clusterhead bears extra load compared to other nodes and more likely to die early because of excess energy consumption. This may result in network partition and communication interruption. Hence it is necessary to balance the energy consumption among mobile nodes to avoid failure due to energy drain. Energy –efficient clustering manages the use

of energy among mobile nodes in a MANET. Thus avoiding unnecessary energy consumption or by balancing energy consumption among different mobile nodes the network lifetime can be significantly increased. IDBLC [31], Wu's algorithm [32], Ryu's algorithm [33], Liu and Lin scheme [34], Ad hoc Network design Algorithm [35], HEEDC [36], Base station control [37], Power aware TDMA [38] and Dynamic link shutdown [39] are some of the energy efficient clustering algorithms.

- ***Mobility***: These schemes take the mobility behavior of mobile nodes into consideration. This is because the mobile nodes' movement is the main cause of changes to the network topology. By grouping mobile nodes with similar speed into the same cluster, the intra-cluster links can be greatly tightened and the cluster structure can be correspondingly stabilized in the face of moving mobile nodes. MOBIC [41], DDCA [43], Kai Liu's protocol [44] and Mobility Based clustering [45] are some mobility aware clustering schemes.
- ***Cluster node degree***: In a clusterhead based MANET, a cluster can handle an optimum number of mobile nodes. A more number of mobile nodes in a cluster may overload the clusterhead thus causing its battery to drain. This could lead to frequent clusterhead changes resulting in multiple path breaks and hence may reduce the system throughput. A less number of mobile nodes in a cluster may form large number of clusters and increase the length of routes resulting in longer end –to-end delay. Load balancing clustering attempt to set upper and lower limits on the number of mobile nodes in each cluster so that clusters are of uniform size. Thus, distributing the network load more evenly in each cluster. AMC [46], DLBC [47], S. Ghiasi Algorithm [48] and Manousakis-Baras scheme [49] are some of the examples of load balanced clustering schemes.

Gap in Existing Research

Clustering is important for a network to achieve scalability in presence of a large number of mobile nodes and high mobility. However, constructing and maintaining a cluster structure usually requires additional control overhead compared to a flat-based structure in an ad hoc wireless network. This additional control overhead involved in clustering is a key issue to validate the effectiveness and scalability enhancement of a cluster structure.

Methodology

Based on the objectives set for the present study and the background work reported in literature with their limitations, the methodology of the present study is proposed as follows:

Phase 1: Literature Survey

A detailed literature survey will be carried out for finding the limitations of experimental work and mathematical models and obtaining the various extractive systems for wireless Ad-hoc network from literature. Continuous literature survey will be carried out to collect the information required during various stages of the proposed research. The source of this literature survey will be various available journals like, IEEE, Computer Society of India, ACM, Sprenger etc., internet sites and e-journals source like Science Direct subscribed through library.

Phase 2: Experimental Set-up

In the second phase of the research work, there will be set-up of an experimental platform to carry out the experiments. Purchasing of software to simulate the proposed work such as MET LAB, C/C++ Compiler, and NS-2 (free open source software).

Various kinds of clustering base algorithms related to wireless adhoc network will be simulated and simulated result will be compared. An optimized cluster based routing protocol will be proposed for mobile adhoc network.

Phase 3: Equilibrium Experiments

In this phase, proposed optimized cluster based algorithm will be simulated with existing cluster based mobile adhoc network. With these experiments allocation performance of existing and proposed optimized mobile adhoc network will also be carried out to determine the performance of cluster based algorithms base on various key factor.

Phase 4: Analysis of Results

Analysis of experimental results will start after first experiment and will be continued to till end of the experiments. From the developed experimental data, suitable/optimum combination of new cluster base algorithm will be proposed. Same combination will be used for further research work.

Phase 5: Mathematical Modeling

A mathematical model will be formulated on the basis of cluster based mobile adhoc network. It will be a mathematical interpretation of cluster based adhoc network. Using the mathematical model, parametric study and sensitivity analysis will be carried out to get the effect on the performance of an optimized cluster based adhoc network.

Phase 6: Economic Evaluation

After the experiments and modeling final economic evaluation of an optimized cluster based routing algorithms for mobile adhoc network will be performed. Economical evaluation will give the economical feasibility of the cluster based mobile adhoc network to improve clustering overhead and packet delivery fraction, average end-to-end-delay, channel utilization, normalized routing load, control overhead in packets and control overhead in bytes respectively.

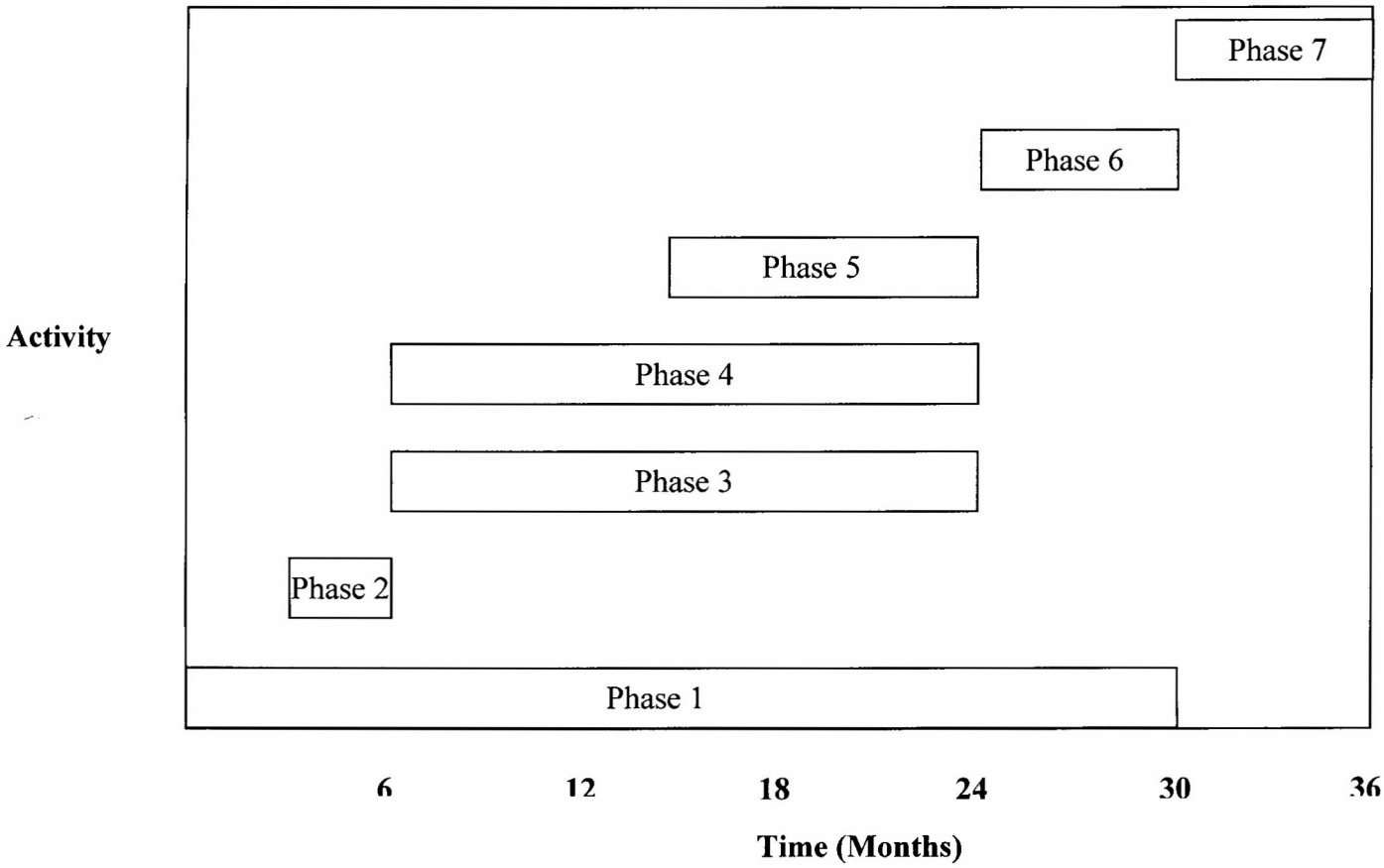
Phase 7: Conclusion and Thesis writing

In this phase, all the experimental and theoretical work carried out in different phases will be documented in the form of thesis.

Work Plan

The work-plan for the above-mentioned seven activities is shown in figure 1.

Figure 1: WORK PLAN



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